PROJECT: WATERQUAL
SYSTEM: RAS – based on literature review
PARTNER: Nofima
CONTACT: Jelena Kolarevic
(jelena.kolarevic@nofima.no)

CtrlAQUA

Recommendations for production of Atlantic salmon postsmolt in RAS

DURATION: 2018-2023

BACKGROUND:

The purpose of this work is to collate results from CtrlAQUA and the literature to provide recommendations for production of Atlantic salmon postsmolt in RAS. The recommendations from CtrlAQUA are based on the research done primarily in controlled environment and are related to specific Atlantic salmon sizes and studied performance, health and welfare indicators. The recommendations should be considered with above mentioned restrictions in mind and should be updated to include new knowledge in the field.

RECOMMENDATIONS:

- Temperature in RAS should be kept at 12oC or bellow during production of Atlantic salmon postsmolt as no positive effects on growth have been observed at higher temperatures and to avoid sexual maturation and potential hearth deformities.
- Carbon dioxide concentration in brackish RAS should be kept below 15 mg/L as growth potential of postsmolt is clearly affected already at 12 mg/L CO2. Salmon in freshwater RAS can tolerate concentrations up to 20 mg/L without any observed effect on growth.
- Salinity of 12ppt has been shown to have positive effect on growth, water treatment process, feed conversion rates, survival and skin health in comparison to higher salinities (22 and 32 ppt). In comparison with freshwater, the positive effect of brackish water (12ppt) on postsmolt growth is inconclusive.
- Use of chloride is necessary if postsmolt is produced in freshwater RAS where nitrite nitrogen concentrations are above 0,1 mg/L to avoid accumulation of this compound in plasma and potential extracellular hyperkaliemia that can have negative effect on heath health. Until Cl-:NO2-N for postsmolt is established existing recommendation of Cl-:NO2-N ratio over 104:1 for smolt should be used.
- Nitrate has no negative effect on growth or sexual maturation and health of postmoslt up to 100 mg/L in freshwater RAS. Presence of NO3-N in brackish and seawater RAS can mitigate negative effect of H2S on postsmolts.
- Ozone corresponding to ORP of 350mV is max that can be used in brackish RAS with Atlantic postsmolt. Long term exposure to similar concentration (320mV) in combination with higher temperature (15oC) in FW RAS can cause sexual maturation. Ozone can change the composition of the organic matter in RAS water and the effects of this on fish are largely unknown.
- Paracetic acid up to 1 mg/L can be used as disinfectant in RAS loop.
- Hydraulic retention time in RAS tanks should be below 45 min.
- Optimal relative water velocity for Atlantic salmon postsmolt is between 1-1,5 body length/s. Higher velocities can improve growth but compromise health and welfare of animals.

- Full Spetra LED (“sunlike”) or White LED of at light intensity of at least 0,2µmol/m2/s secures good growth, external morphology and doesn’t promote sexual maturation in postsmolts in brackish RAS. Further increase in light intensity does not have further positive effect on above mentioned indicators. Led lights with predominant peak in blue light spectra should be avoided in RAS with deep tanks or with turbid water.
- Postsmolt density up to 1kg should be kept below 80 kg/m3 in RAS to prevent negative effect on growth and welfare.
- 24h light photoperiod has positive effect on postsmolt growth in RAS but reduces growth in seawater phase of production. Current results indicate that this photoperiod can be used in RAS to produce large postmolts (>150 g to 850 g) without negative effect on sexual maturation. More data on the effect of photoperiod on other welfare indicators and fish physiology are needed before final recommendations on optimal photoperiod during postsmolt production are made.
- Postsmolt size: Traditionally produced 100-150 g postmolts using 12L:12D photoperiod has better growth, survival, resistance to winter ulcers and body weight is seawater phase at autumn transfer. Increased postsmolt size at autumn transfer results in shorter production period in the sea but also reduces growth and survival and is not the best production strategy. Current data indicate that postsmolt size and season of transfer can be closely related. More research and results on this corelation are needed.

The factsheet is ready for implementation, but with the note that the testing has not been done for all industrial relevant conditions.

READ MORE:

DELIVERABLE 5.4/2022 Updated WATERQUAL protocol for production of Atlantic salmon post-smolt
DELIVERABLE 5.1/2019: Summary of the latest findings for water quality requirements and best management practices for salmon post-smolts, including relevant findings from the farm surveys

Parameter	Value	Known and investigated effect	References
Temperature	12°C	Welfare, health, growth, maturation in FW RAS	Bæverfjord et al. (2013), Crouse et al., (2022)
Salinity	5-12 ppt (size related)	Water quality, growth, FCR, survival, skin health, color, lower maturation rate during RAS phase only. Positive effect of brackish water on TGC in RAS observed, but inconclusive.	Ytrestøyl et al. (2020), Bakke et al. (2016), Fang et al. (2021); Ytrestøyl (2022b).
CO_2	<15 mg/L	Growth rate, body weight in brackish water but no effect on nephrocancinosis prevalence or long-lasting effect on blood physiology; No effect on growth in fresh water	Mota et al. (2019, 2020), Good et al. (2018)
Nitrite-N	<0,1 mg/L (fresh water)	Chronic exposure to higher and oscillating concentrations leads to increase in NO2-N plasma levels and extracellular hyperkaliemia (Cl^- was not added to freshwater)	Mortensen et al. (2022)
Nitrate-N	≤100 mg/L	No effects on health, physiology, maturation in fresh water-RAS	Good et al. (2017), Davidson et al. (2017)
Ozone - O_3	<350mv ORP in brackish RAS and FW RAS	Welfare, improved gill health, Changes in organic composition of RAS water; better growth in FW RAS and better water quality but higher maturation	Stiller et al. (2020), Lazado et al. (2021), Davidson et al. (2021), Aguilar-Alarcón et al.(2022)
Paracetic acid (PAA)	1ppm	Strong adaptive responses at systemic and mucosal levels in post-smolts	Osório et al. (2022)
HRT	<45 min	Water quality, tank hydrodynamics	Gorle et al. (2020), Summerfelt et al. (2016)
Light intensity and spectra	Full Spetra LED or White LED of at least 0,2µmol/m^2/s	No effect on growth and morphological welfare indicators; Intensity affected by water quality and depth (reduced intensity and changed spectra). Further increase in intensity does not have additional positive effects on fish.	Meriac et al. (2020)
Density	<80 kg/m^3 (up to 1 kg post-smolt)	Higher density affects welfare, growth, health, cataracts, skin health, mortality, feed conversion rate, chronic stress in 12ppt RAS and freshwater RAS	Bæverfjord et al. (2013), Kolarevic et al. (2016)

Photoperiod	24h light (>150 to 850 g) for growth (based on current results)	Higher growth rate in RAS and bigger final weight at slaughter for postsmolts >100 g; no effect on mortality in RAS and in the sea phase; no effect on selected immunity indicators (Ytrestøyl 2022). No effect on maturation up to 150 g in commercial setting (Martinez 2021) but high temperatures after transfer to seawater can lead to increase in maturation (Ytrestøyl, 2022b). Effect of season at transfer on growth-out phase in sea	Ytrestøyl et al. (2022a), Martinez et al. (2021), Ytrestøyl (2022b)
Handling		Skin health	Karlsen et al.. (2017), Ytrestøyl et al. (2013)
Size at transfer	100-160 g (12h light: 12 darkness) for autumn transfer to sea	Best performance in sea, largest harvest average weight, no maturation, best resistance to winter ulcers. Season of transfer might play much bigger role for larger smolts at transfer (more results from BENCHMARK to come).	Ytrestøyl et al. (2022[a,b])
Water velocity	1-1.5 BL/s	Growth, health, welfare	Timmerhaus et al. (2020), Gorle et al. (2020), Ytrestøyl et al. (2020)

Additional information: Full references from Table 1. are provided in the DELIVERABLE 5.4/2022 Updated WATERQUAL protocol for production of Atlantic salmon post-smolt.